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Current status of research on *Aleurodicus dugesii* (Hemiptera: Aleyrodidae) on dutch eggplant

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Abstract. *Yuliadhi KA, Listihani L, Selangga DGW, Sudiarta IP, Wirya GNAS, Temaja IGRM. 2024. Current status of research on* Aleurodicus dugesii *(Hemiptera: Aleyrodidae) on dutch eggplant. Biodiversitas 25: 2241-2248. Aleurodicus dugesii* Cockerell whitefly is considered to be a polyphagous insect which can parasitise a wide variety of hosts. Horticultural crops are the commodity most dominantly attacked by *A. dugesii.* Information on population density, damage severity, and genetic diversity of *A. dugesii* in Indonesia is still limited. This research aimed to determine the population density, the damage severity, and the genetic variety of *A. dugesii* at an eggplant cultivating center in Kintamani District, Bangli, Bali. The research was conducted on 8 plantations in Kintamani District. The *A. dugesii* was identified through morphology and molecular method of Polymerase Chain Reaction (PCR). *Aleurodicus dugesii* egg placement characteristics are circular, following the wax path formed, and at the underside of the leaf, there would be soft, long wax filament resembling a beard produced during the nymph stage. The highest *A. dugesii* whitefly population in duct eggplant crops during nymph, pupae, and imago stages were 184.6, 131.3, and 152.2 individuals per leaf. In Kintamani District, the highest damage severity reached 62%. The highest nucleotide homology of *A. dugesii* DNA cytochrome oxidase subunit I (COI) was found in the same species from Indonesia and the US, with >97% resemblance. This research enriches the information about the widening *A. dugesii* distribution area in Indonesia.

Keywords: Biodiversity, level of damage, population, *Solanum betaceum*, whitefly

Abbreviations: COI: Cytochrome Oxidase Subunit I, DNA: Deoxyribonucleic Acid, PCR: Polymerase Chain Reaction

INTRODUCTION

Whitefly (Hemiptera: Aleyrodidae) is a group of insects that is an important pest on several types of plants, such as the Solanaceae family chili (*Capsicum annuum* L and *Capsicum frutescens*), tomato (*Lycopersicum esculentum* Mill.), eggplant (*Solanum melongena*). Adult winged insect actively moves places by flying between plants or plantations while pre-adult form attaches to the underside of plant leaves. Whiteflies have a piercing-sucking mouth type (haustellata), which generally causes damage to plant cells or tissues that can cause tissue necrosis. During feeding, whitefly will excrete fluid (saliva) that contains enzyme which can help break down plant cell wall. The eases the insect to suck the fluid from plant cells. Continuous loss of plant fluid can cause the plant to wither and suffer from abnormal growth or stunting (Leybourne and Aradottir 2022). This fluid (saliva) can also become the medium from which plant viral disease spreads. The movement of viruliferous whiteflies (containing viruses) between plants or plantations may affect the spread of plant diseases (Moreno-Delafuente et al. 2013).

Whitefly presence in Indonesia has been known since the 1900s. During that time, the family of this insect was known as Aleurodidae. One of the whitefly groups that is a pest in Indonesia is the genus *Aleurodicus.* In Indonesia, three species of whitefly from the genus *Aleurodicus* were found, namely *A. destructor*, *A. dispersus*, and *A. dugesii*. According to Hidayat et al. 2018, the whitefly *A. destructor* no longer belongs to the genus *Aleurodicus* but has been changed to the genus *Aleuroctarthus*. Koningsberger reported there were three whitefly species which were important pests in sugarcane crops in Java, which were *Aleurodes bergi* Sign, *A. longicornis* Zehnt, and *A. lactea* Zehnt. Nugnes et al. (2020) further reported three other whitefly species, which were *Aleurocanthus spiniferus* Quaint, *Aleurodicus cocois* Corb, and *Aleurodicus destructor* Mask. At that time, *A. destructor* became an important pest that attacked fruit trees and coconuts in Java. During the 1930s, Kalshoven and Vecht reported 20 whitefly species (Kalshoven 1981), including species that have been reported by Koningsberger and Dammerman. Based on research by Hidayat et al. 2018 in Bogor, West Java, 17 whitefly species that have never been reported before were found. In total, 37 species known to exist in Indonesia were found in both agricultural and non-agricultural plants.

Whitefly research in Indonesia is still limited to species such as *Bemisia tabaci* Genn and *Trialeurodes vaporariorum* West. Both species were vectors for viral plant diseases. Other whitefly species that are important pests in Indonesia are *Aleurodicus dispersus* Russell and *A.*

dugesii Cockerell. *Aleurodicus dispersus* and *A. dugesii* are native insect from South America with widely diverse hosts. In 1989, *A. disperses* was known to have spread on part of Java and Sumatra, with the number of host plants reaching 22 species from 14 plant families (Hidayat et al. 2018; Hidayat et al. 2020). *Aleurodicus dugesii* was first reported at 2007 in Bogor by Hidayat et al. (2018) which invaded hibiscus plant (*Hibiscus rosa-sinensis*). Not only in Indonesia, the attack of *A. dugestii* apparently also invaded a number of countries such as Texas in 1991, California in 1992, Louisiana and Florida in 1996, Hawaii in 2002, Belize, Costa Rica, El Salvador, Guatemala, Mexico, Nicaragua, Venezuela, Pakistan and Hawaii (Schoeller and Redak 2018b).

Aleurodicus dispersus and *A. dugesii* are cosmopolitan whitefly species with a diverse range of host plants (Hidayat et al. 2018). Murgianto research showed that *A. dispersus* has 111 host species from 53 plant families, while *A. dugesii* has 40 species from 27 plant families. Most of *A. dispersus* and *A. dugesii* host plants are from horticultural crops (vegetables, fruits, and decorative plants) (Hidayat et al. 2018; Hidayat et al. 2020).

Giant whitefly is known to cause direct and indirect damage to plants, especially on commercially cultivated crops. Giant whitefly produces soft and long white wax filament resembling a beard, which can cover an entire leaf (Hidayat et al. 2020). The wax may be blown by the wind and can lower the beauty of decorative plants (Schoeller et al. 2018). The nursery industry in California suffered a 3.4 billion US dollar economic loss per year due to giant whitefly infestation (Bellows and Hoddle 2010).

So far, results have been lost because the attack of *A. dugesii* is not yet known. However, the presence of commodities horticulture needs to be wary of because this pest is afraid it will spread throughout Indonesia, including neighboring countries such as Southeast Asia and South Asia (Ortiz-Urquiza and Keyhani 2013), because *A. dugesii* reputation is quite feared. During his lifetime, *A. dugesii* sticks to the bottom surface leaves so they are not easily washed away by water because protect themselves with wax thread. In addition, its position attached to the lower surface of the leaves makes it often avoid spraying insecticides commonly used by farmers. Therefore, plant cultivation horticulture should be aware of the emergence of *A. dugesii*, especially in the dry season (Schoeller and Redak 2018b).

In Indonesia, information on the population, damage severity, and genetic diversity of giant whiteflies is very limited. Thus, a research project on population density, plant damage severity and giant whitefly isolate genetic identity in Indonesia is crucial to making whitefly control efforts, especially in agricultural crops, could be performed successfully. This research aimed to determine the population density, damage severity, and molecular identity of giant whiteflies in dutch eggplant crops in Bali, Indonesia.

MATERIALS AND METHODS

Sampling

Giant whitefly sampling was performed on five plots in dutch eggplant plantations in Kintamani District, Bangli Regency, Bali, Indonesia. Sampling was performed using purposive sampling method. Leaves infested by pupae or whitefly exuvia were taken and covered by tissue paper, then put into clear plastic bags, labeled, and taken to the Integrated Pest Management Laboratory, Faculty of Agriculture, Universitas Udayana, Indonesia.

Dutch eggplant damage observation

Plant damage observation was performed based on the *A. dugesiii* whitefly infestation symptoms appearing on the plants, such as white wax filament on the leaves, sooty mold on the leaves, withering leaves and dead plants. Damage calculation was performed by visual estimation. Direct estimation was performed on each observed plant, and afterwards, certain damage value was determined. The damage evaluation was performed by dividing the plants into four observation plots. On every plot, the percentage of damaged leaves was observed and then calculated (for one dead plant, the damage value was 100%).

Dutch eggplant damage severity

On each plantation (8 plantation) in Kintamani District, the total number of dutch eggplant crops, the number of infested plants, and the number of plants without infestation were calculated. This was performed to determine the level of *A. dugesii* infestation on dutch eggplant crops. Plant observation on every location or plantation was calculated with the use of counters.

Giant whitefly population density observation

The nymph, pupae, and imago population observations in tree plants were performed by sampling 12 leaves from every plant's upper, middle, and lower parts, in which 4 leaves were taken by the four cardinal directions. Leaves that would be taken for observation were cut and put inside transparent plastic. Determination of sample plants was performed by taking 15 plants diagonally. The calculation of the nymph, pupae, and imago population was performed in the laboratory by using a hand counter tool, stereo microscope, and magnifier.

Molecular identification of giant whitefly by Polymerase Chain Reaction (PCR)

DNA extraction was performed using a cetyltrimethylammonium bromide (CTAB) method. PCR reaction was made to a total volume of 25 µl, consisting of 12,5 µl Go Tag Green Master Mix (Promega, US) and 9.5 µl ddH_2O. The amplification of DNA fragment COI was performed by using a pair of universal primers COI LCO 1490 (3'-GGTCAACAAATCATAAAGATATTGG-5') and HCO 2198 (5'TAAACTTCA GGGTGACCA AAAAATCA-3') for 1 µl each, and 1 µl of template DNA. PCR reaction was performed using Perkin Elmer 480 Thermocycler (Applied Biosystem, US). PCR reaction was started by denaturation initiation for 5 minutes at 94ºC. PCR followed for 35 cycles with the following order: 94ºC for 1 minute, 52ºC for 35 seconds, 72ºC for 1 minute 30 seconds, and final elongation at 72ºC for 7 minutes. PCR results were then analyzed using 1% agarose gel, which had been added by FluoroVue dye. The observation of DNA fragment COI was visualized by a UV transilluminator and captured by a digital camera.

Analysis of DNA sequence results

Amplification result via PCR technique was in the form of COI DNA fragment ± 710 bp in length, which was analyzed in 1st Base, Ltd., Malaysia. The DNA fragment COI sequences was analyzed by software Bioedit versi 7.0.9.0. The DNA sequences were analyzed for similarities against DNA sequences available in National Centre Biotechnology Information (NCBI) (http://www.ncbi.nlm.nih.gov/) site by using the program basic local alignment search tool (BLAST). The homology of giant whitefly DNA fragment COI against others deposited in the NCBI was analyzed by using the program ClustalW BioEdit. The phylogenetic information based on DNA sequences was made with the help of the software Molecular Evolutionary Genetic Analisis (MEGA 6) by using UPGMA with 1,000 repetitions bootstrap.

RESULTS AND DISCUSSION

The imago of *A. dugesii* a mosaic pattern or black spots on its wings (Figure 1.A, B, C). The male and female imago of *A. dugesii* have the same body size. *A. dugesii* imagos have an abdomen to separate them both. In the male imago, the organ is an elongated claw at the end of the abdomen, while the female imago did not have the organ (Figure 1.B). This claw is the male genital which may appear from the eighth, ninth, or tenth abdominal segment.

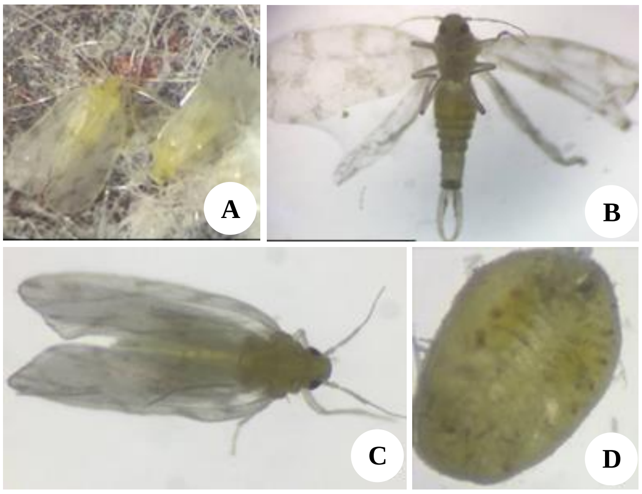

Figure 1. Imago (A, B, C), pupa (D) *Aleurodicus dugesii* on dutch eggplant in Kintamani District, Bangli, Bali, Indonesia

Aleurodicus dugesii whitefly pupae (Instar 4 nymph) morphology appears clear and is often found under the surface of leaves in groups. Their outside appearance is a bit oval and by the abdomen six pairs of porous and two pairs of reduced pores could be found (Figure 1.D). The dorsal circle has segmented pore pattern at the sub-median area and most of the pores are thick and a bit big. The pore lines at the submarginal area are not interrupted by vasiform orifice. Two pairs of posterior pores are reduced and bell-shaped. Lingula elongated and at times overlapped with the posterior margin (Schoeller and Redak 2018a).

The whitefly *A. dugesii* has a paurometabolous type of metamorphosis. In general, immature insects with this type of metamorphosis are called nymphs. The metamorphosis of this insect starts from the egg, develops into a nymph, and then develops into an imago. Eggs are produced by female *A. dugesii* imago. The female imago is able to produce 150-300 eggs during its lifetime (Madushani and Sirisena 2024). Fertilized female imago by the male imago will attach his eggs to the leaf surface with a hook called a pedicel. Whitefly *A. dugesii* reproduce sexually, but occasionally parthenogenetic. An unfertilized female imago will produce male offspring.

Paurometabolous insects also include other insects with simple metamorphosis. Winged adults and nymphs live in the same habitat, during which major changes occur in size, body proportions, development of a single eye, and sometimes the shape of other structures. In this metamorphosis the wings are formed outside of the immature stage, and usually there is no pupa stage before the last molt.

During metamorphosis there are changes called histolysis and histogenesis. Histolysis is a process of breaking down broken larval structures into materials that can be used in the development of adult structures. Histogenesis is the process of development of mature structures from the products of histolysis (Vaca et al. 2019). The main sources of material for histogenesis are hemolymph, body fat and soluble tissues such as larval tendons and ectoderm structures. The wings and limbs develop under the cuticle of the larva as epidermal thickenings called imaginal discs. These tissues respond in very different ways from other larval tissues to the insect hormonal environment. At the end of the larval instar, these tissues work to form the adult structure. Other organs may be preserved from larva to adult or may be completely rebuilt sexually (Yakovlev et al. 2022).

Before the eggs hatch, the future whitefly nymphs get food from the host plant (Boughton et al. 2015; Derocles et al. 2015; Francis et al. 2022). First instar nymphs have limbs to move in search of a suitable and permanent place for absorption of food there. The next phase, the whitefly nymph has no legs so that it cannot move even though the environmental conditions do not support it around the absorption area. In the last stage, whiteflies stop feeding activity and form a puparium before becoming an imago. After going through the pupa stage, the whitefly becomes an imago. Whitefly imago *A. dugesii* has a body size of 4-5 mm. The whitefly *A. dugesii* is the largest whitefly species compared to other species. The imago of the whitefly

Bemisia tabaci only has a body size of 1-2 mm and *A. dispersus* measuring 2-3 mm (Francis et al. 2022).

In the summer and winter in Florida, the life cycle from egg to imago took around 25-30 days (Francis et al. 2022). Meanwhile, according to Perring et al. (2018), *A. dugesii* took 35 days to complete one life cycle in Florida during summer and winter. *A. dugesii* has 6 developmental stages, which are egg, instar 1 nymph, instar 2 nymph, instar 3 nymph, instar 4 nymph, and imago. Figure 1 shows the pupae phase (instar 4 nymph) and *A. dugesii* whitefly imago.

Female adult insects deposited the eggs they made into the wax they produced. The eggs are placed circularly following the path of the wax formed (Figure 2.A). The wax is usually formed in a concentric pattern at the underside of the surface of the leaf (Nasruddin and Stocks 2014). The wax is produced by female imago insects when they are about to lay egg on host plants, while male imago does not produce wax (Schoeller and Redak 2018a). *Aleurodicus dugesii* whitefly reproduces sexually (they seldom reproduce by parthenogenesis). Female imago that has not mate (2N) will produce male offspring (1N). Fertilized eggs will become 2N offspring (Curnutte et al. 2014). Female imago can produce 150-300 eggs throughout her life. A female insect that has been fertilized by a male insect will attach her eggs on the surface of the leaf with a special hook called the pedicel. During the egg stage, whitefly prospective nymph will acquire their food by taking fluid from the host plant (Schoeller and Redak 2018a).

Aleurodicus dugesii infestation symptoms are unique in that the underside of the leaf will have fine, long white wax filaments resembling bread produced by the nymph phase (Figure 2.B). When invading a plant, *A. dugesii* excretes honey dew which cause dust to gather on the leaf, causing plants that are severely infested to look dirty and attracting ants (Naranjo et al. 2015). Moreover, honeydew is used as a medium for the growth of black soot mold (Figure 2.B). Black soot mold hinders the photosynthesis process because the sunlight is blocked by the layer of soot on the surface of the leaf (Simberloff 2012). If the *A. dugesii* population is high, the entire leaves may be covered by wax layer (Wetherington et al. 2017). It is assumed that *A. dugesii* adapts to cold weather through the wax it produces. The wax layer from *A. dugesii* is thicker and longer compared to other whitefly, which can protect *A. dugesii* from cold weather (Schoeller and Redak 2018a).

Whitefly damage *A. dugesii* can be distinguished in the form of direct damage and indirect damage. Immediate damage caused by the eating activity of the piercing nymph and imago phases, sucking leaf fluid, resulting in spots on the leaves or the death of leaf tissue (Figure 2.C). Liquid suction plants carried out by nymphs can also induce physiological disorders plant (physiological disorder) such as irregular maturity of plants tomato and silver leaf on a plant of the Cucurbitaceae family. Indirect damage is in the form of honeydew excretion which is used as a medium for the growth of soot dew. The soot dew itself hinders the process photosynthesis because sunlight is blocked by a layer of soot on the surface leaf. The losses incurred range from 20-100% depending on the plant and seasons and the relationship between these insects and other factors.

In Indonesia, *A. dugesii* whitefly has been found in many areas in West Java, including Bandung, Cianjur, Sukabumi, Subang and Garut (Hidayat et al. 2018; Hidayat et al. 2020). According to Francis et al. (2022) the distribution of *A. dugesii* includes California, Florida and Hawaii. Schoeller and Redak (2018b) reported the distribution of *A. dugesii* includes Arizona, Louisiana and Texas, Canada, Central America, South America, Africa, Costa Rica, Belize, Guatemala, Mexico, Nicaragua, Venezuela, and the Canary Islands. The discovery of *A. dugesii* in Kintamani, Bali indicates an increasing area of distribution in Indonesia.

Host plant was most invaded by *A. dugesii* in Kintamani District on the 2nd and 8th planting, with the nymph, pupae, and imago populations respectively being (184.6; 131.3; 152.2) and (159.1; 121.3; 121.4) individuals per leaf (Table 1). The lowest *A. dugesii* population was during the 5th planting, with the average nymph, pupae, and imago population being 29.8, 31.9, and 26.5 individuals per leaf. The average *A. dugesii* population from the 1st to 8th planting showed a relatively high population. This is due to the dutch eggplant crops being the main host of *A. dugesii*. This result is supported by Hidayat et al. (2020), who showed that the highest *A. dugesii* population was found in dutch eggplant crops, which was 1,986 individuals per leaf.

The assessment of host plant damage severity was based on the symptoms visible on the plants, which are white wax filament on a leaf, soot mold on a leaf, dry leaf, and plant death. In Kintamani District, the highest damage was found in the 2nd planting of 62% while the lowest damage was in the 5th planting of 25%. The highest damage is the percentage of the host plant showing the most severe symptoms due to *A. dugesii* infestation in the form of wrinkling and yellow leaves. The symptoms due to *A. dugesii* invasion on dutch eggplant crops in Kintamani District can be seen in Figure 2.B & C, which are yellow wrinkling leaves, white wax filament, and leaf malformations.

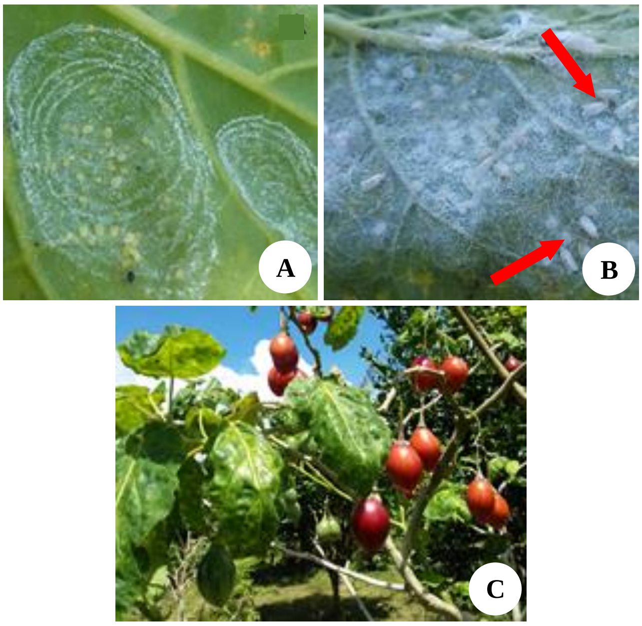

Figure 2. Pattern of egg laying by female imago of *Aleurodicus dugesii* on dutch eggplant leaves (A); symptoms of *A. dugesii* attack on dutch eggplant (B, C); arrows indicate white wax filaments

The forward and reverse primers can amplify COI DNA well, as seen in the DNA band from 1 until 8, which are the amplification results of *A. dugesii* COI DNA. The first to eighth DNA band belongs to dutch eggplant crops from Kintamani District, Bangli Regency, Bali. The DNA band showed matched the desired target, which is around ±710 bp in length (Figure 3). Based on BLAST result, the nucleotide sample of *A. dugesii* found in Bali, Indonesia, on dutch eggplant has >97% similarities with the same species obtained from Indonesia and the United States (Table 2). Different species of *A. dugesii* within the same genus shared nucleotide homology of >85% to <90% (Table 2). The phylogenetic tree of *A. dugesii* Bali isolate, Indonesia on dutch eggplant is within one group with the same species from Indonesia obtained from orange plant and from US, while being in a different group from other species (Figure 4).

Other than using morphological analysis for identification process, sequence analysis is a technique known to be the best in observing the diversity of a group of organisms. In principle, diversity and polymorphism can be seen from the DNA order or sequence of certain fragments of an organism's genome (Lee et al. 2013; Khamis et al. 2021). Based on the research result, there are three *A. dugesii* sequences, each of which has almost the same length and nucleotide sequence because the three samples are at the same taxonomy level. This is in line with the research from Alhudaib et al. (2014), Jamsari et al. (2014), Ovalle et al. (2014), Dickey et al. (2015), and Chen et al. (2016), where the use of COI DNA sequence in whitefly identification can differentiate whitefly to species level.

Aleurodicus dugesii is often found in fruit plants, one of which is dutch eggplant. Fruit plants have large and complex sizes so that they can provide a large living space for various types of organisms, including whitefly. Nasruddin and Stocks (2014); Schoeller and Redak (2020); Triwidodo and Listihani (2020); Listihani et al. (2022); Temaja et al. (2022); Hutasoit et al. (2023); Listihani et al. (2023a, b); Selangga et al. (2023) stated that there was an increase in the number of herbivorous species with increasing plant size and complexity. In addition, the complex structure of the plant can protect insects from their natural enemies. Most fruit plants belong to dicotyledonous plants. Schoeller and Redak (2020); Khamis et al. (2021); Selangga and Listihani (2021); Selangga and Listihani (2022) reported as many as 136 species of whitefly found on dicotyledonous plants, while as many as 17 species were found on monocotyledonous plants.

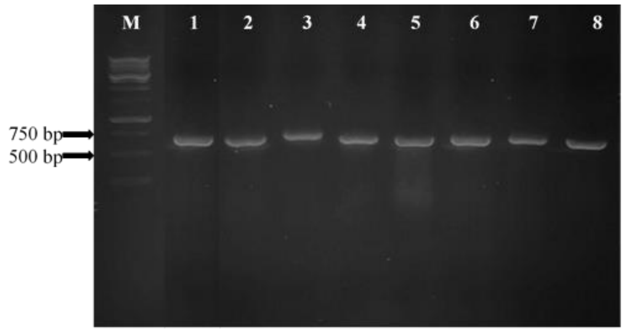

Figure 3. The results of DNA visualization of *Aleurodicus dugesii* using universal primer LCO 1490/HCO 2198. 1. Kintamani 1; 2. Kintamani 2; 3. Kintamani 3; 4. Kintamani 4; 5. Kintamani 5; 6. Kintamani 6; 7. Kintamani 7; 8. Kintamani 8; and M. DNA marker 1 kb (Thermo Scientific)

Table 1. Damage level and population of nymphs, pupae, and imago of *Aleurodicus dugesii* on dutch eggplant in Kintamani District, Bangli, Bali, Indonesia

Locations	Damage rate (%)	Population average (individuals/leaf)		
		Nymphs	Pupae	Imago
1	46	103.2	108.5	107.8
2	62	184.6	131.3	152.2
3	32	35.6	84.1	25.5
4	35	42.1	89.2	38.1
5	25	29.8	31.9	26.5
6	37	48.7	81.2	41.8
7	51	107.8	118.1	112.6
8	59	159.1	121.3	121.4

Table 2. Homology of DNA nucleotide of COI *Aleurodicus dugesii* from Bali, Indonesia, with other species from GenBank

Species	Source	Accession number	Homology (%)		
			Kintamani 2	Kintamani 5	Kintamani 8
Aleurodicus dugesii	Indonesia	LC491422	99.17	99.13	99.12
Aleurodicus dugesii	United States	AY521251	97.80	97.82	97.81
Aleurodicus dispersus	Spain	LN614548	88.85	88.72	88.73
Aleurodicus dispersus	China	EU581837	88.76	88.79	88.72
Aleurodicus dispersus	China	EU581838	88.73	88.71	88.71
Aleurodicus dispersus	India	MZ356499	88.72	88.69	88.71
Aleurodicus dispersus	India	KY574540	88.57	88.57	88.54
Aleurodicus dispersus	India	KY574539	88.57	88.57	88.54
Aleurodicus dispersus	DR Congo	MN022644	88.14	88.16	88.19
Aleurodicus rugioperculatus	India	MW750575	86.83	86.78	86.81
Aleurodicus rugioperculatus	India	MK159733	86.80	86.80	86.80
Aleurodicus rugioperculatus	India	MW041900	86.80	86.79	86.76
Aleurodicus rugioperculatus	India	MK159729	86.78	86.78	86.75
Aleurodicus rugioperculatus	India	MK159727	86.78	86.76	86.73

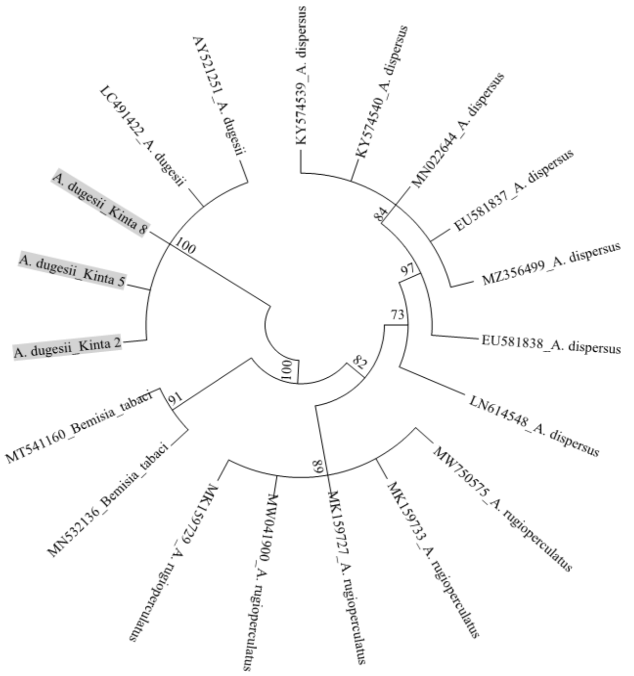

Figure 4. Phylogenetic tree of *Aleurodicus dugesii* using COI DNA, sequences with silver highlights are Bali sequences from dutch eggplant

Groups of fruit plants are also generally a type of annual plant that can provide a source of food and a longer habitat for whitefly. Therefore, whiteflies are more commonly found in woody plants (trees) than vegetables, ornamental plants, and other plants that have a simple structure.

Aleurodicus dugesii is a new pest with limited distribution with diverse host and can cause death on plants, making this pest as a crucial pest which requires attention. The identification of *A. dugesii* in dutch eggplant in Bali showed that its distribution has spread in Indonesia. This whitefly is known to invade 43 genus from 35 families of plants in the Southern United States (Li et al. 2021; Simmons and Riley 2021). Meanwhile, according to Bellows and Hoddle (2010), there are around 200 species from 35 families of plants which could be the host of *A. dugesii*. This pest generally attacks decorative plants in nurseries, landscapes, and home yards. The plants most invaded are begonia, hibiscus, orchid, banana, mulberry, aralia, various types of vegetables, orange, and avocado (Bellows and Hoddle 2010). In Indonesia, *A. dugesii* invades dutch eggplant, okra, bottle palm tree, ivory betel, common bean, Surinam cherry, nightshade berry, lemongrass, grass jelly, string bean, winged bean, and horticultural crops are the commodities dominantly invaded by *A. dugesii* (Hidayat et al. 2018; Hidayat et al. 2020).

The large number of hosts allows the whitefly population to exist throughout the year in both the main and alternative hosts and indicates that this pest is polyphagous. The attack pattern in each village is generally almost the same (Hidayat et al. 2020). This is because the geographical conditions and the commodity crops that grow in each village are not too different (Hidayat et al. 2020).

A. dugesii with a high population found in dutch eggplant in Kintamani was found in the planting. This is in accordance with the research of Hidayat et al. (2020) which states that *A. dugesii* is dominantly found in the yard compared to agricultural and forestry land. Care of plants that grow in the yard is less attention to pest control. Most plants only grow with less intensive care. Treatment is only in the form of watering carried out by the plant owner. On agricultural land, whitefly populations are found in low populations (Barad et al. 2022). Intensive insecticide application is carried out by farmers with the aim of optimizing the production of cultivated plants and suppressing pest populations.

Aleurodicus dugesii is commonly found in dutch eggplant in Kintamani which is a highland area. This is in accordance with the research of Hidayat et al. (2020) which mentioned that *A. dugesii* ticks tend to be found in highlands such as Cipanas. *A. dugesii* adapts to cold air through the wax it produces. The waxy layer of *A. dugesii* is thicker and longer, so it can protect *A. dugesii* from cold air. This insect has become a major pest on dutch eggplant plants in the Kintamani area, almost all dutch eggplant plants are attacked with a heavy level of attack. The high ability to reproduce and the large number of individuals cause the death of the host plant, so that it has the potential to become a pest in the future. Legg et al. (2014) states that the lowlands are at an altitude of 0-500 m above sea level, the medium land is 500-1000 m above sea level and the highlands are > 1000 m above sea level.

Based on the results of direct observations in the field as well as observations in the laboratory, there were natural enemies that were found to be associated with *A. dugesii*, which belongs to the group of predatory insects. Predatory insects found included the beetle *Menochilus sexmaculatus*, *Coccinella transversalis*, *Verania lineata* (Coleoptera: Coccinellidae), and the praying mantis *Hierodula ovata* (Mantodea: Mantidae).

The honeydew produced by whiteflies can also be a source of food for other insects, including predatory insects such as Chrysopidae, Coccinellidae, Cantharidae, Tachinidae, Syrphidae, and various types of Hymenoptera parasitoids (Abd-Rabou and Simmons 2014). The above statement explains that there is a tritrophic relationship between host plants, herbivorous insects, and their natural enemies. This is what can be one of the factors that affect the presence and abundance of whitefly populations in the field.

Based on the result, to prevent serious economic loss and even wider distribution, control effort is required. One of the distribution routes of this pest is transporting it with a transport media (plant) distributed between regions. Thus, one of the effort in preventing pest distribution is conducting health inspection on *A. dugesii* host plants before being distributed in and out of Indonesia as well as between areas within the Republic of Indonesia. Thus, this pest must be classified as Quarantine Plants Disturbance Organism. It is recommended for related institutions to conduct a survey on *A. dugesii* distribution region or to determine regions free of or invaded with *A. dugesii*. The economical loss estimation can be used as a basis to recommend classifying whitefly as Quarantine Plants Disturbance Organism Category A2.

In conclusion, the highest population of whitefly *A. dugesii* on dutch eggplant during the nymph, pupae, and imago phases are 184.6, 131.3, and 152.2 individuals per leaf, respectively. The level of damage severity on the leaves of dutch eggplant crops due to giant whitefly *A. dugesii* infestation ranged between 32-62%. The nucleotide homology on COI DNA of *A. dugesii* is highest with the same species from Indonesia and the United States, which is >97%.

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